Scenarios and Projections for COVID-19 in Arizona

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DRAFT materials prepared for the

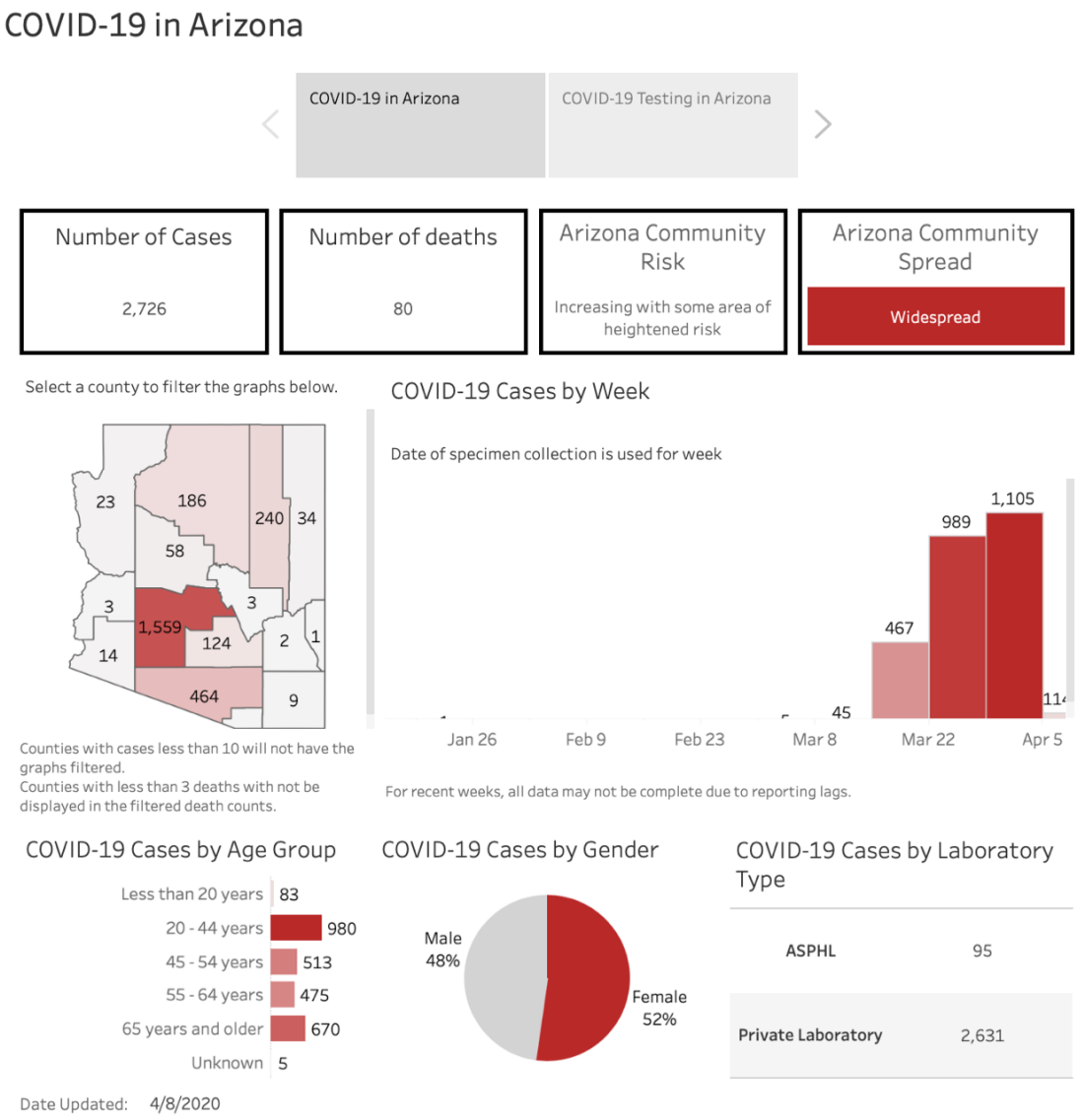
Arizona Department of Health Services – Modeling Working Group

AZ Situation Update: Data and Modeling WG

- Impossible to know if contribution to increased cases is due to increased testing or spread of disease.
- Change in testing criteria on 3/28 – no longer testing symptomatic.
- Increased severity of social-distancing measures 3/16, 3/21, and 3/31.
- Estimates for undetected cases in the US are currently around 1 in 11 (9%-14%).
- ADHS has assembled this modeling working group to prepare projections for state.

April 1, 2020 Situation Update

- Daily forecasts derived from ADHS and commercial lab testing data
- Monitor testing data and public health interventions as the basis of estimates

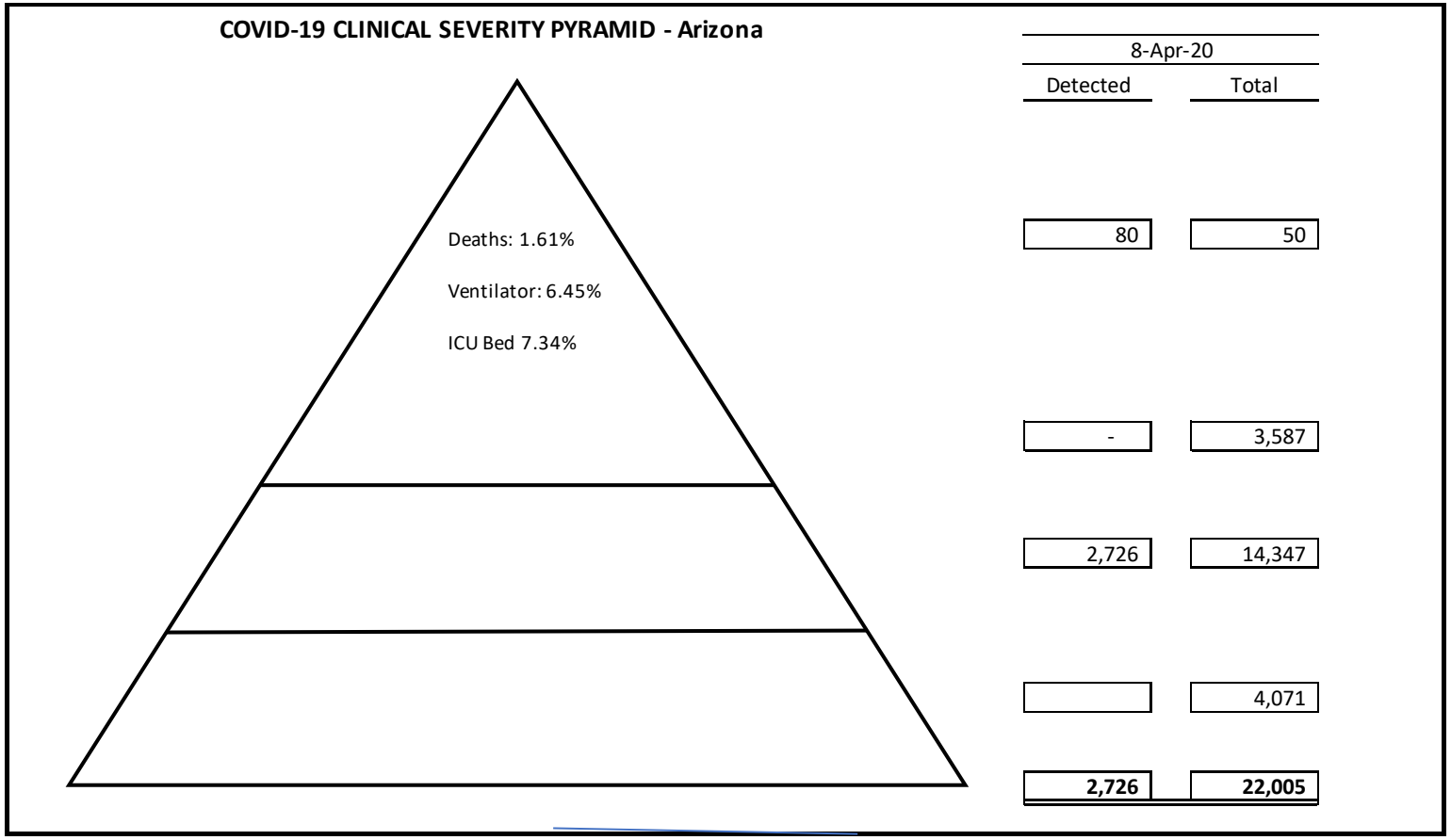


AZ Situation Update

- COVID-19 Testing Results for April 8

8-Apr		Positive	Negative	Deaths	Total
ADHS		2,726	31,838	80	34,564
COVID tracking	8-Apr	151	1,038	7	1,189
Total		2,726	31,838	80	34,564

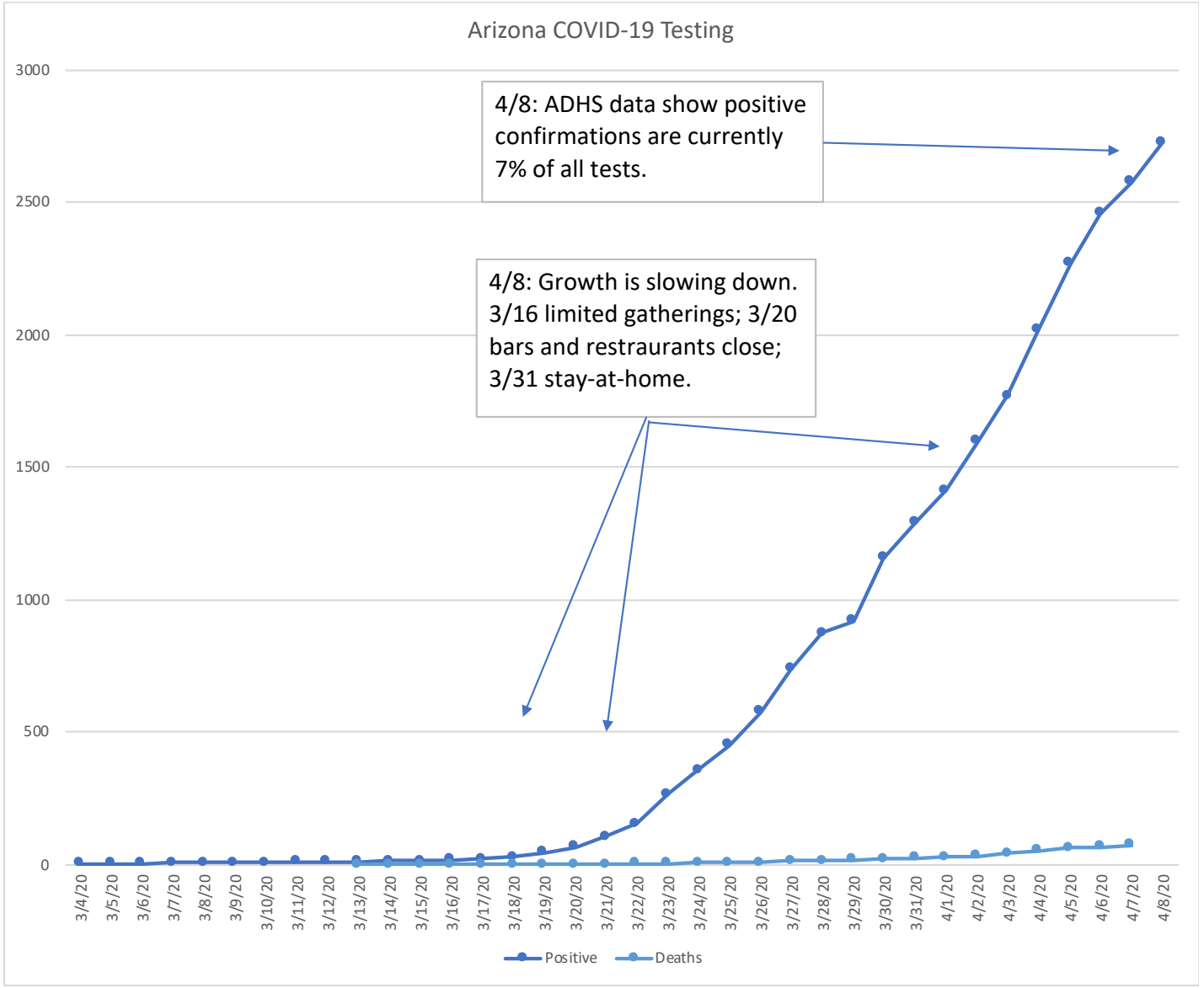
Estimating Undetected Cases



Current estimates from J. Shaman (2020) and A. Perkins (2020) that 9% - 14% of infections are detected.

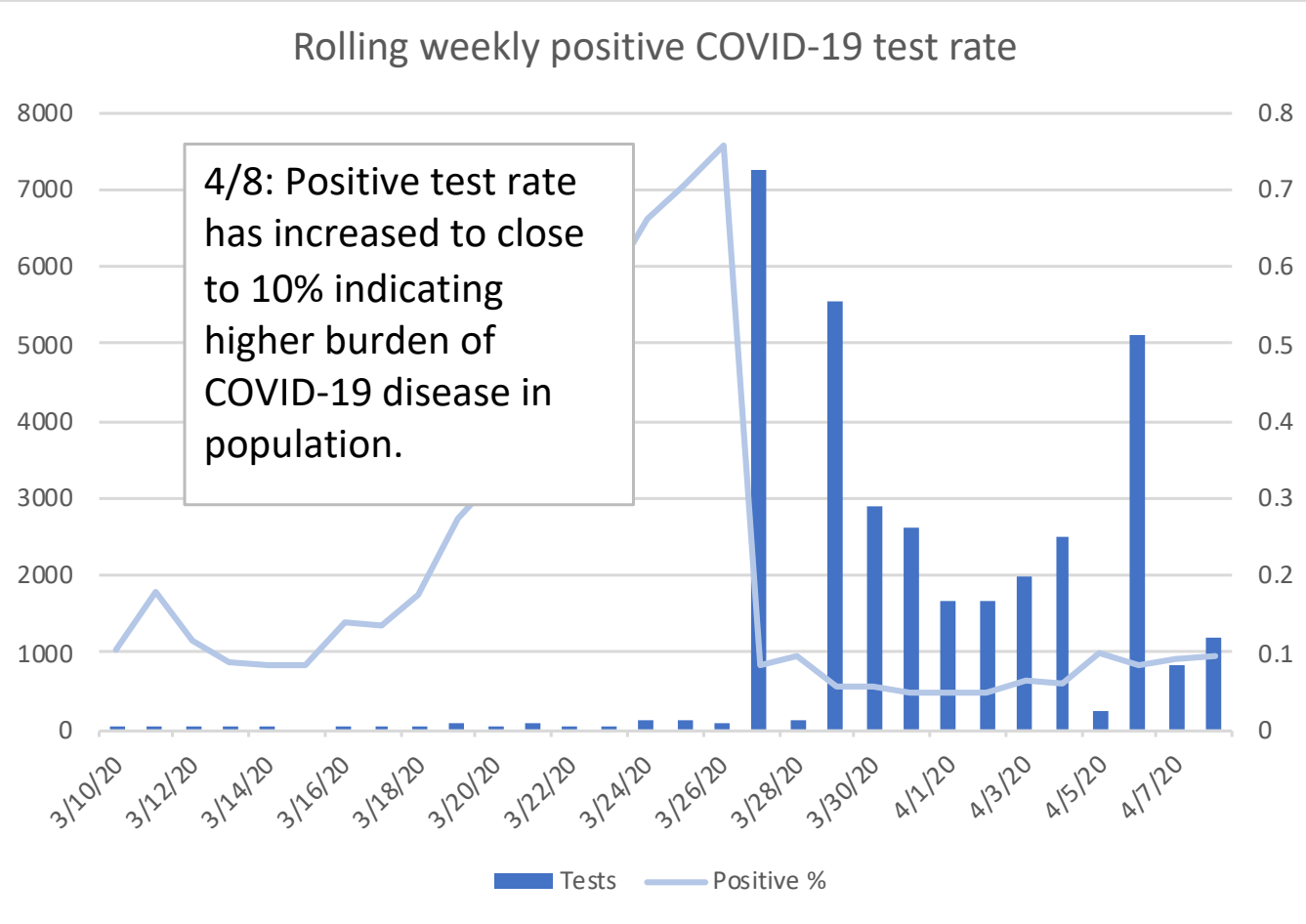
Epidemiology Signal

- Growth is rapid, but has slowed
- Doubling times
  - March 17-24: 1.7 days
  - March 25-April 8: 5.3 days
- Does not include undetected cases



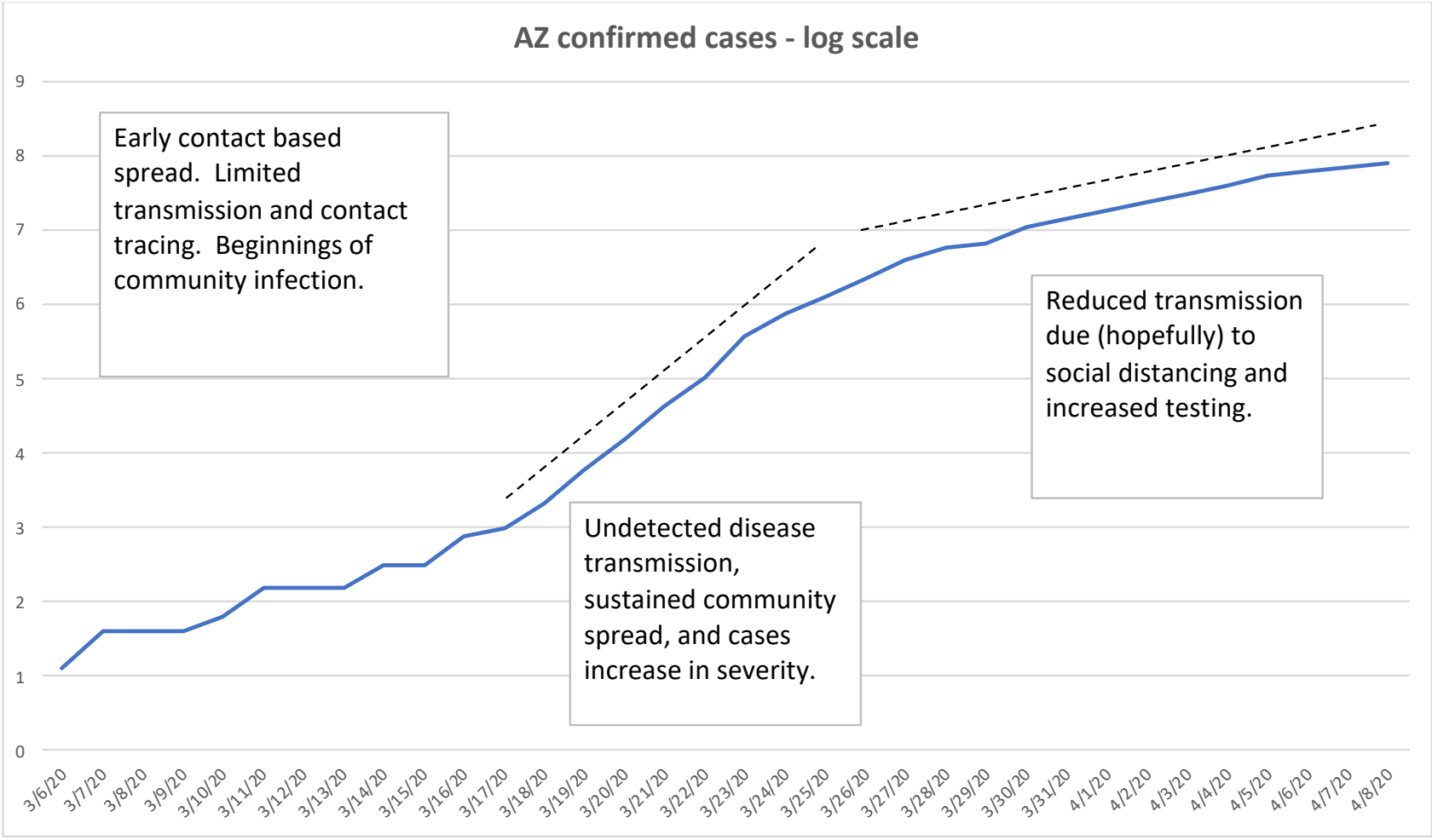
Testing Signal

- Information about negative tests results released March 27.
  - Positive test result drops to <10%.
- Range of 8%-10% is consistent with other US cities with community spread

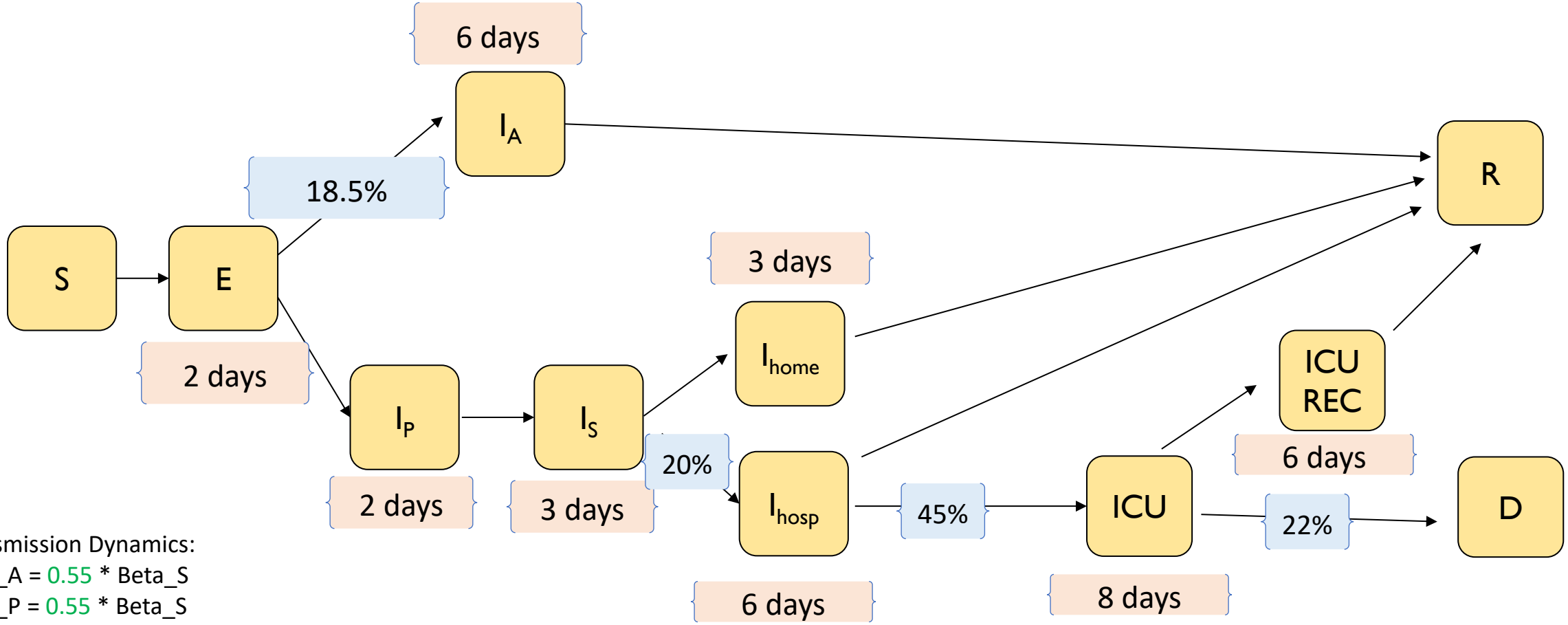


Transmission

- Early stochastic effects
- Fast exponential growth
- Slowing growth



Model1 Details



Transmission Dynamics:
Beta_A = 0.55 * Beta_S
Beta_P = 0.55 * Beta_S
Beta_S = 0.30
Beta_home = 0.20 * Beta_S
Beta_hosp = 1 * Beta_S
Beta_ICU1 = 0.20 * Beta_S
Beta_hosp = 0.20 * Beta_S

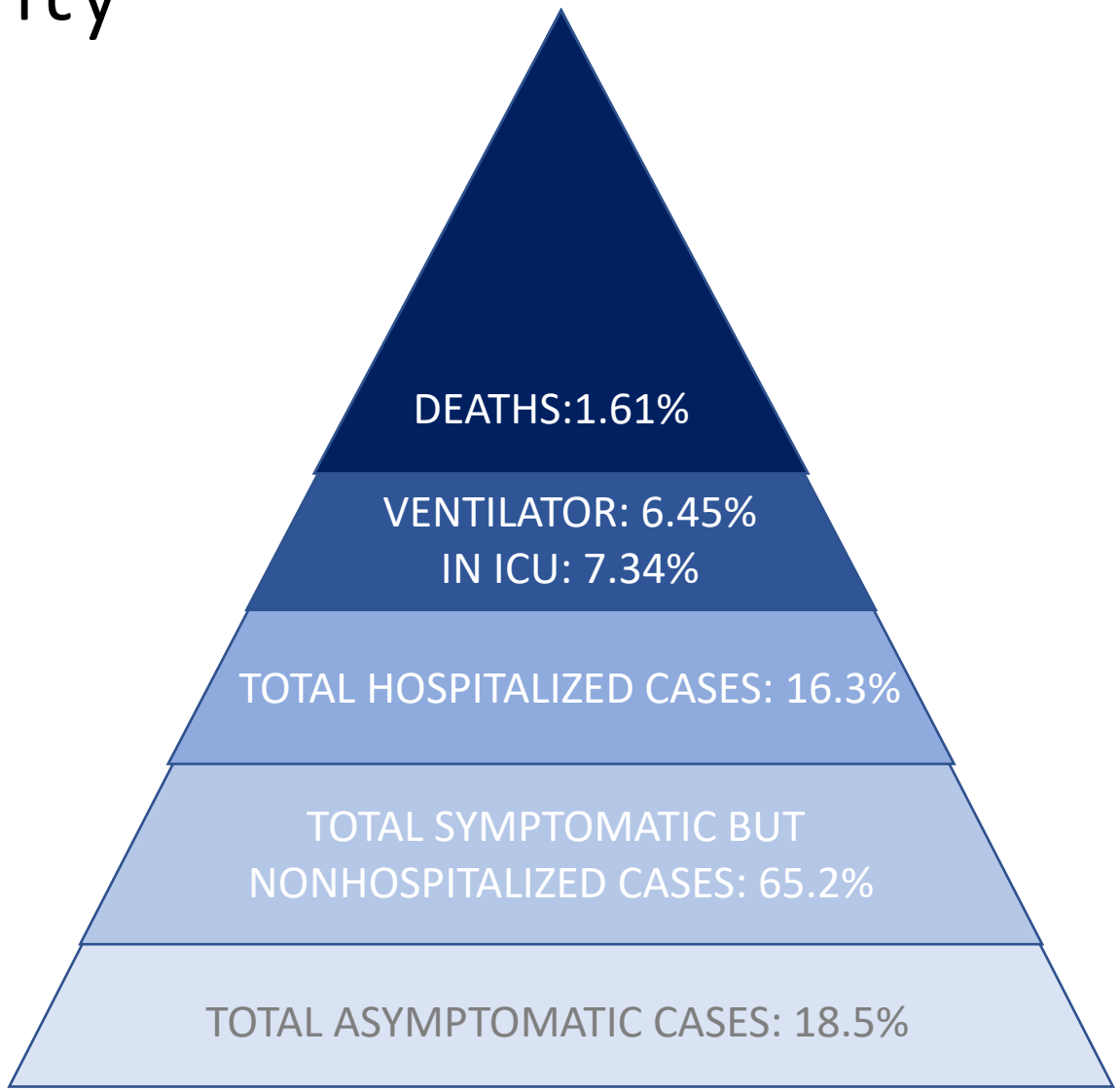
$0.1=0.45*p_D \Rightarrow p_D=22\%$

Results in an overall mortality of 2% among symptomatic individuals

Pyramid of Disease Severity

- The assumed parameters in the model are all sourced from recent results

- The top of the pyramid implies significant healthcare resource requirements



Assumptions & Parameters

Table 1: Estimated parameters for COVID-19 clinical progression, and literature sources

Quantity	Parameter	Value	Source
Incubation Period	$E+I_P$	4 days	Cai et al., 2020; Laio et al., 2020; Lauer et al., 2020;
Proportion of Asymptomatic Infections	A	18.5%	Mizumoto et al., 2020
Asymptomatic viral shedding		0.55	Li et al., 2020
Duration of mild/presymptomatic phase of infection	I_P	2 days	Wei et al., 2020
Infection rate for I_S and I_H cases		0.30	Pei & Shaman, 2020
Duration of LR symptoms before hospital admission	I_S	3 days	Zhou et al., 2020

Assumptions & Parameters

Quantity	Parameter	Value	Source
Duration of infection (Time from symptoms to hospitalization)	I_P+I_S	5 days	Tindale et al., 2020; Ferguson et al., 2020; Chen et al., 2020; Wang et al., 2020; Zhou et al., 2020
Hospitalization rate of Is cases	p_H	20%	Wu et al., 2020
Proportions of hospitalizations that go to the ICU	p_{ICU}	45%	Guan et al., 2020; Wu & McGoogan, 2020
Proportion of mild infections	$1-p_H$	80%	Wu et al., 2020; Yang et al., 2020
Duration of illness from symptom onset		23 days	Verity et al., 2020
Time from symptom onset to death		17 days	Verity et al., 2020; Wu et al. 2020
Case Fatality Rate		2%	Wu et al., 2020
Overall ICU Mortality	p_D	22%	Grasselli et al., 2020

Scenarios and projections

- We considered five scenarios to provide a range of projections on
  - Total number infected – includes asymptomatic and pre-symptomatic
  - Total symptomatic patients – includes all patients who are non-hospitalized
  - Hospitalized patients – patients in regular hospital beds and ICU
  - Patients in ICU
  - Patients on a ventilator

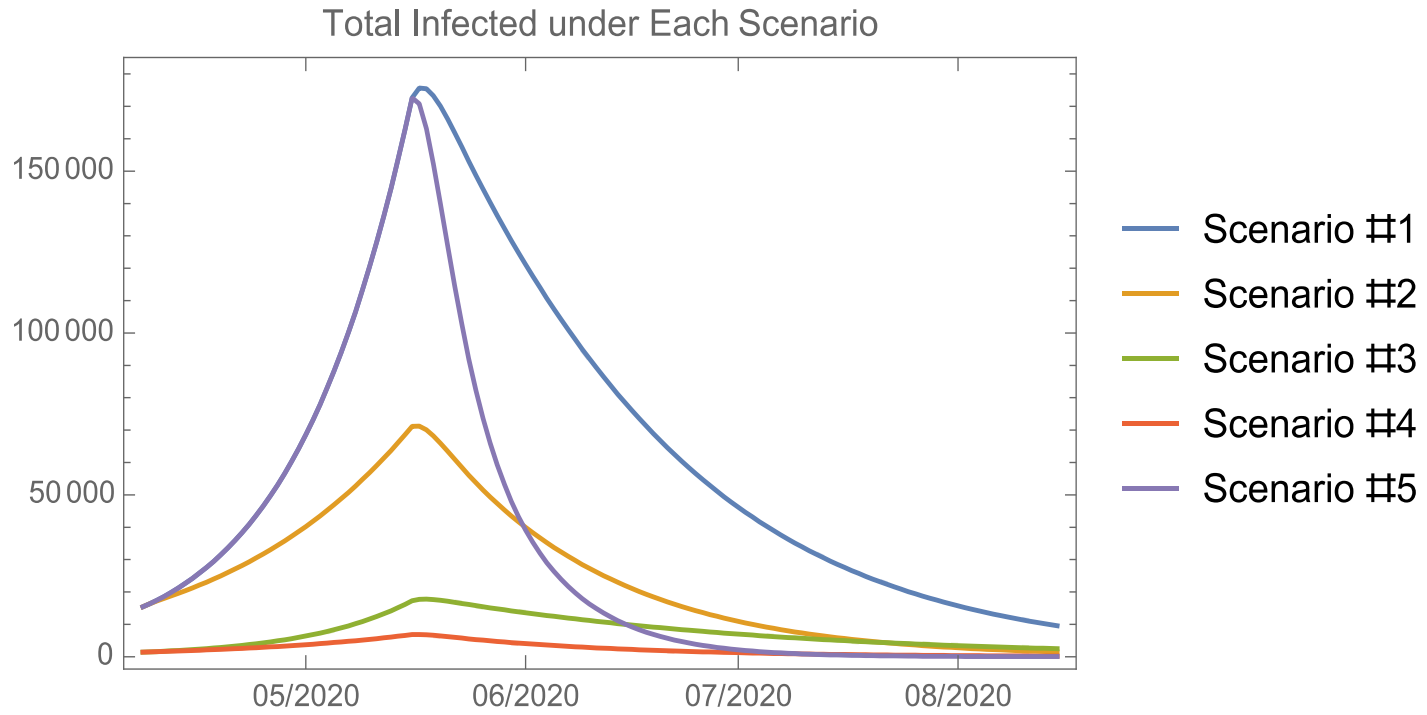
Scenario ID	β_S	Assumed Total Infected Individuals on 4/8/20	Assumed Summer Effect
Scenario#1	0.30	20,383	On May 15, β_S reduces to 0.15
Scenario#2	0.25	20,383	On May 15, β_S reduces to 0.15
Scenario#3	0.30	1,853	On May 15, β_S reduces to 0.15
Scenario#4	0.25	1,853	On May 15, β_S reduces to 0.15
Scenario#5	0.30	20,383	On May 15, β_S reduces to 0.05

Scenarios:

Scenario	Description
Scenario 1.	Assumes all infections are known based on a reporting rate of 9% (18530 initial unreported cases, and 1853 reported cases) and ``moderate" (modeled by transmission rate for symptomatic patients, betaS ~ 0.30) social distancing. The estimate of unreported cases obtained by an estimate provided by Shaman et. al. 2020. Assumes no additional mitigation Summer effect is modeled by reducing betaS by half on May 15.
Scenario 2.	Assumes a reporting rate of **9**% (18530 initial unreported cases and **1853** reported cases) and ``maximal" social distancing (modeled by transmission rate for symptomatic patients, betaS ~ 0.25). Assumes ongoing mitigation Summer effect is modeled by reducing betaS by half on May 15.
Scenario 3.	Assumes that the current reported cases reflect the actual number of infected individuals as of 4/8/20 (1853 initial infected) and moderate social distancing (modeled by transmission rate for symptomatic patients, betaS ~ 0.30). Summer effect is modeled by reducing betaS by half on May 15. Assumes no additional mitigation
Scenario 4.	Assumes that the current reported cases reflect the actual number of infected individuals as of 4/8/20 (1853 initial infected) and maximal social distancing (modeled by transmission rate for symptomatic patients, betaS ~ 0.25), Summer effect is modeled by reducing betaS by half on May 15. Assumes no ongoing mitigation
Scenario 5.	Same as Scenario 1 with extreme summer-time transmission effects (heat or distancing); reduced transmission rate, betaS to 0.05 after May 15. Assumes no additional mitigation for social distancing.

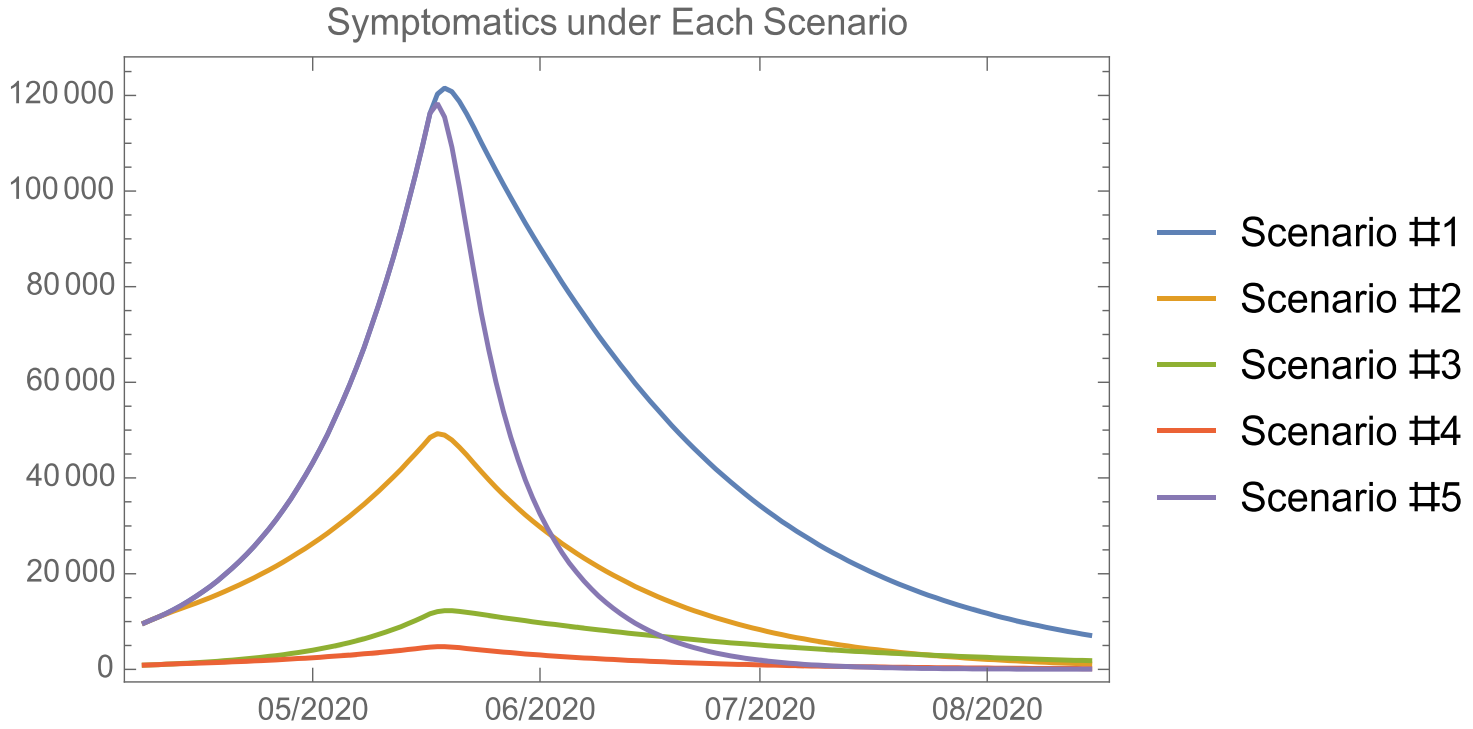
Total Infected

- Total infected includes asymptomatic and pre-symptomatic individuals, who may be transmitting the disease
- The sharp decline in Scenario #5 due to the reduction in transmission rate due to summer effect
  - Assumes May 15 for reduction In transmission
  - Summer effects not yet known



Symptomatic Infections

- A large number of the symptomatic infections will recover at home
  - Due to social distancing measures, we assumed that these individuals with transmit the disease at a lower rate



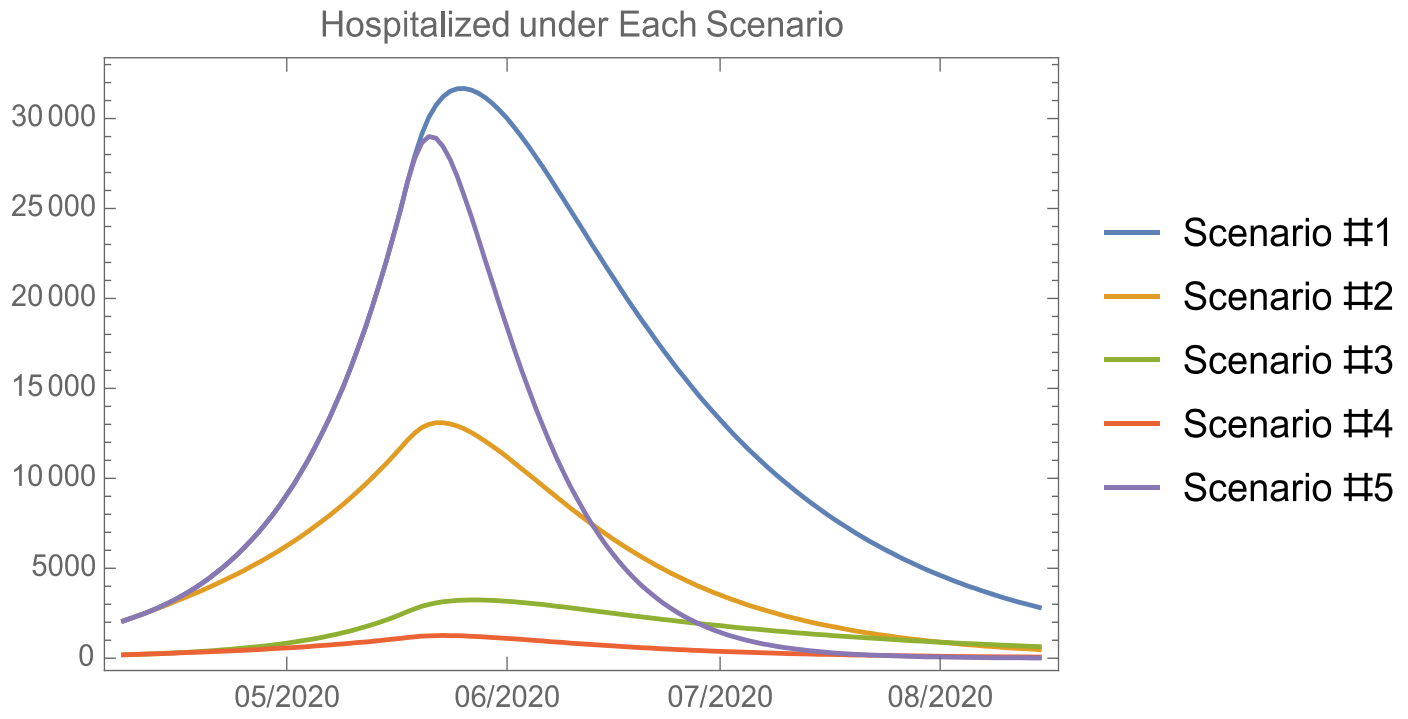
Hospitalized Infections

- A portion of the hospitalized infections are in ICU, which we track separately due to the significant resources need to care for ICU patients
- Under our mid-range scenario (Scenario #2), the number of hospitalized patients hit 13,091 on May 23
- Scenario #4 estimates a max of

1258 patients on May 23, similar to

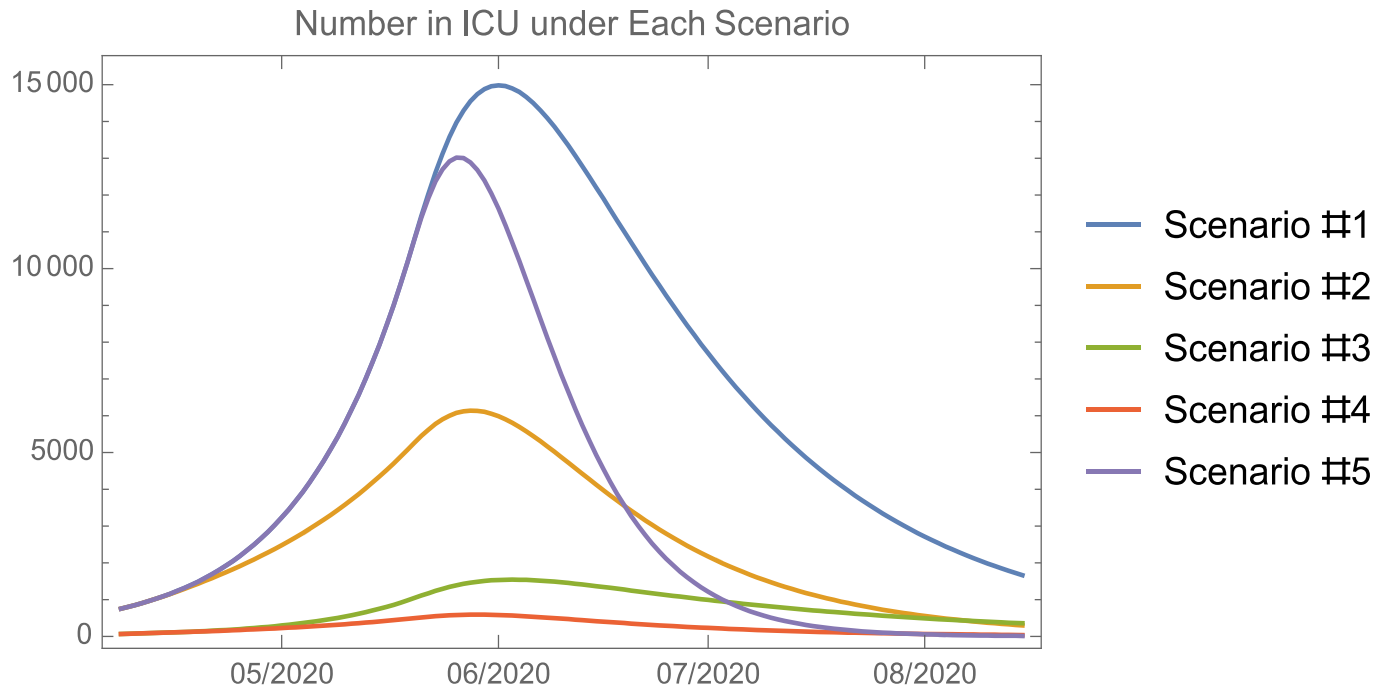
IHME estimates of 1203

on April 22



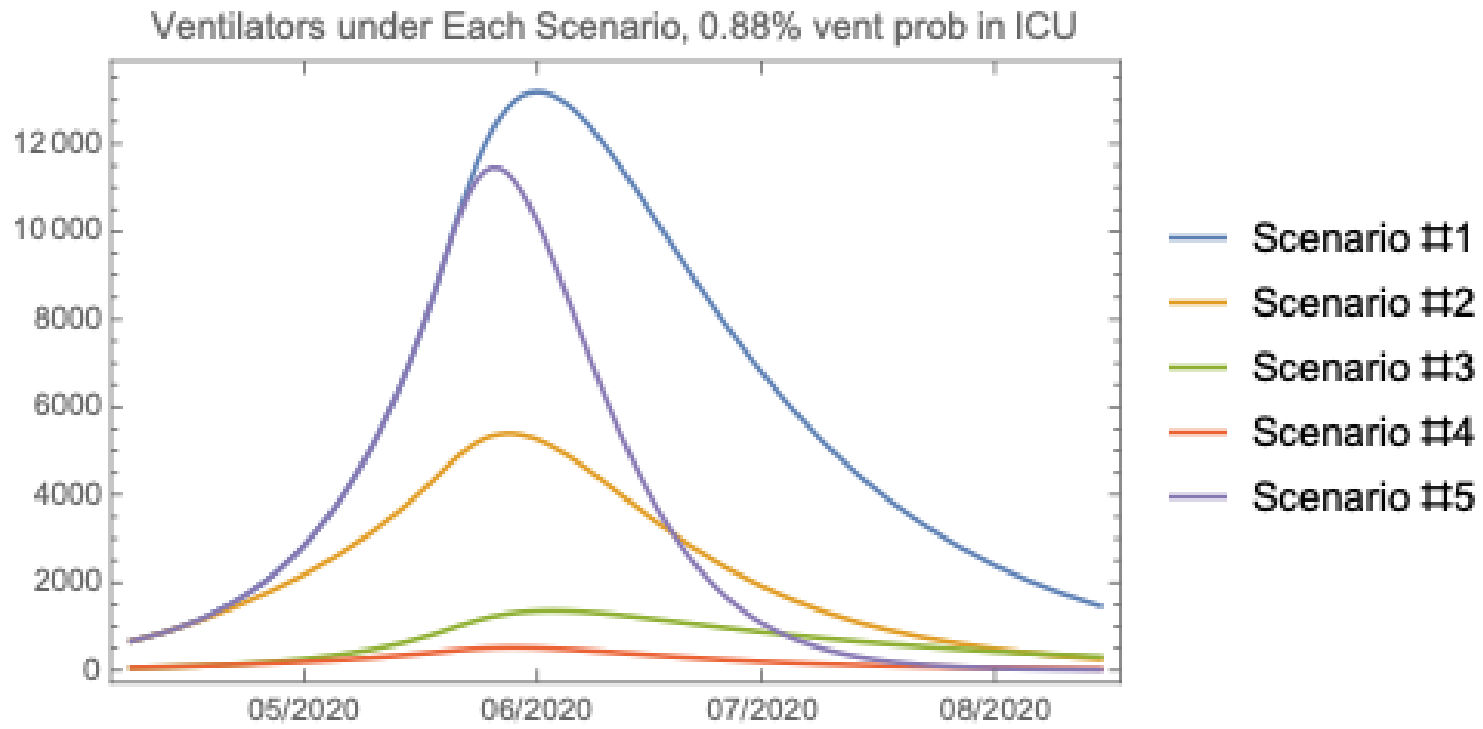
Patients in ICU

- ICU resources can be critical to save lives
- In particular, several sources have pointed to longer ICU stays by patients that eventually recover
- ICU stays can be as long as 14+ days for these patients



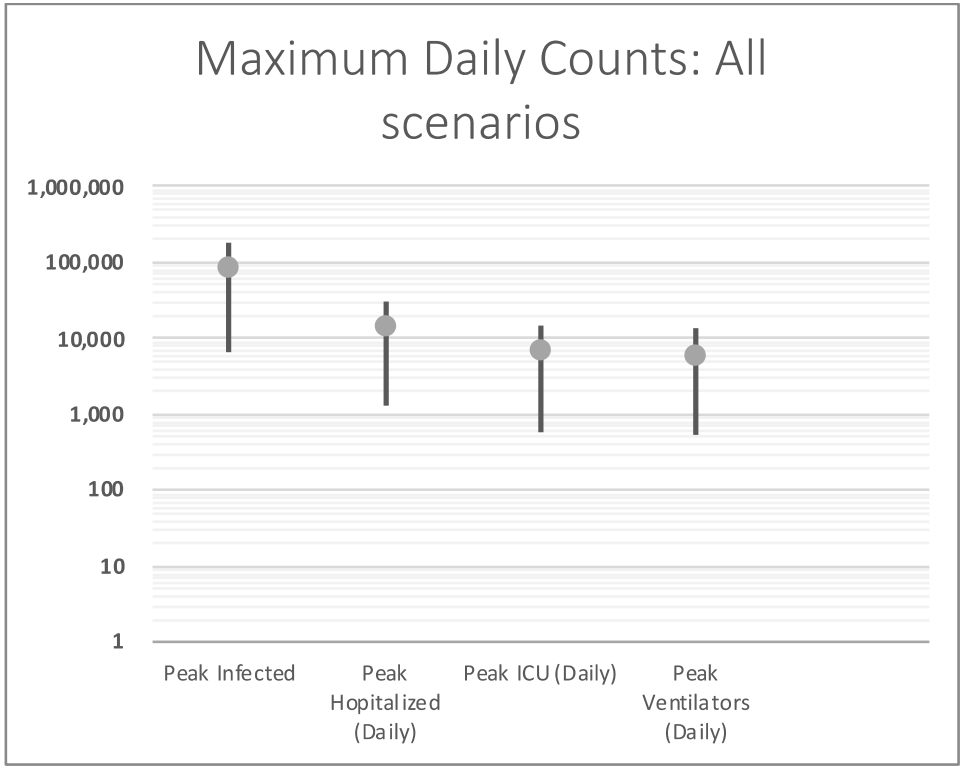
Patients on Ventilator

- A significant fraction of patients (~88%) need mechanical ventilators in ICU
- Rate of mortality among patients on mechanical ventilator is higher than other causes of ARDS (~67%)

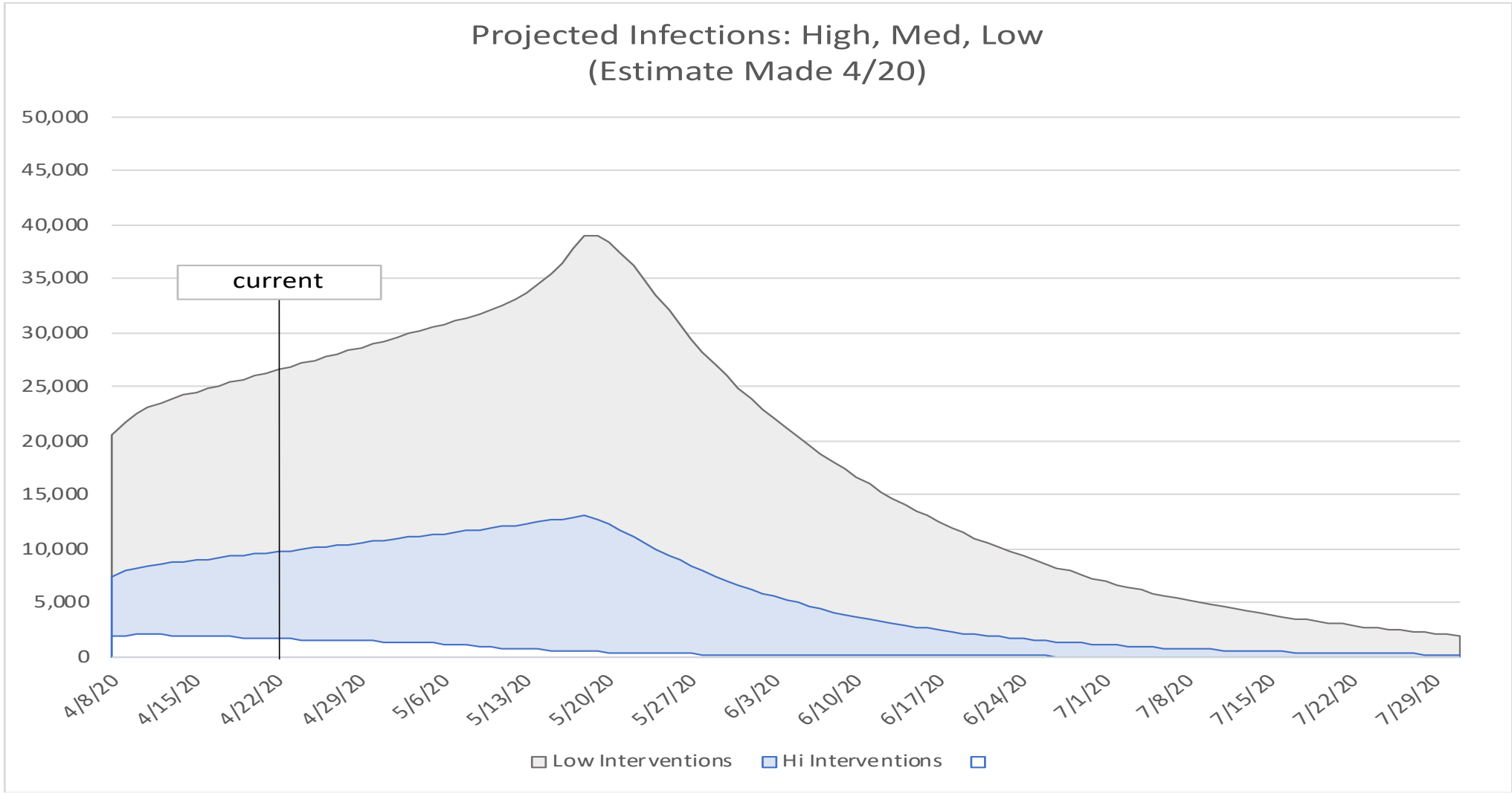


Maximum Daily Counts: All scenarios

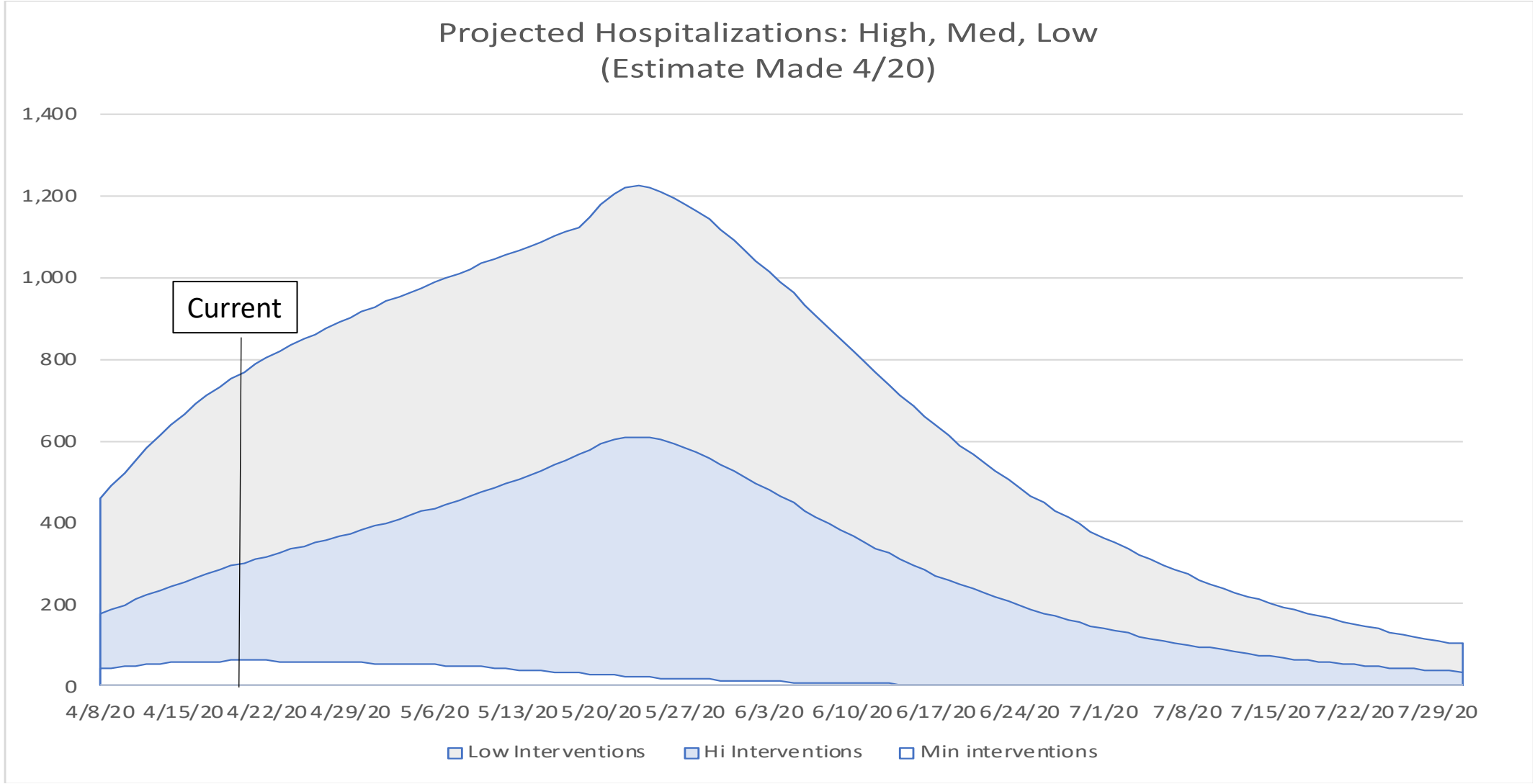
	Low	High	Mid
Peak Infected	6,875	175,695	88,466
Peak Hopitalized (Daily)	1,259	31,670	15,428
Peak ICU (Daily)	591	14,981	7,126
Peak Ventilators (Daily)	520	13,183	6,270



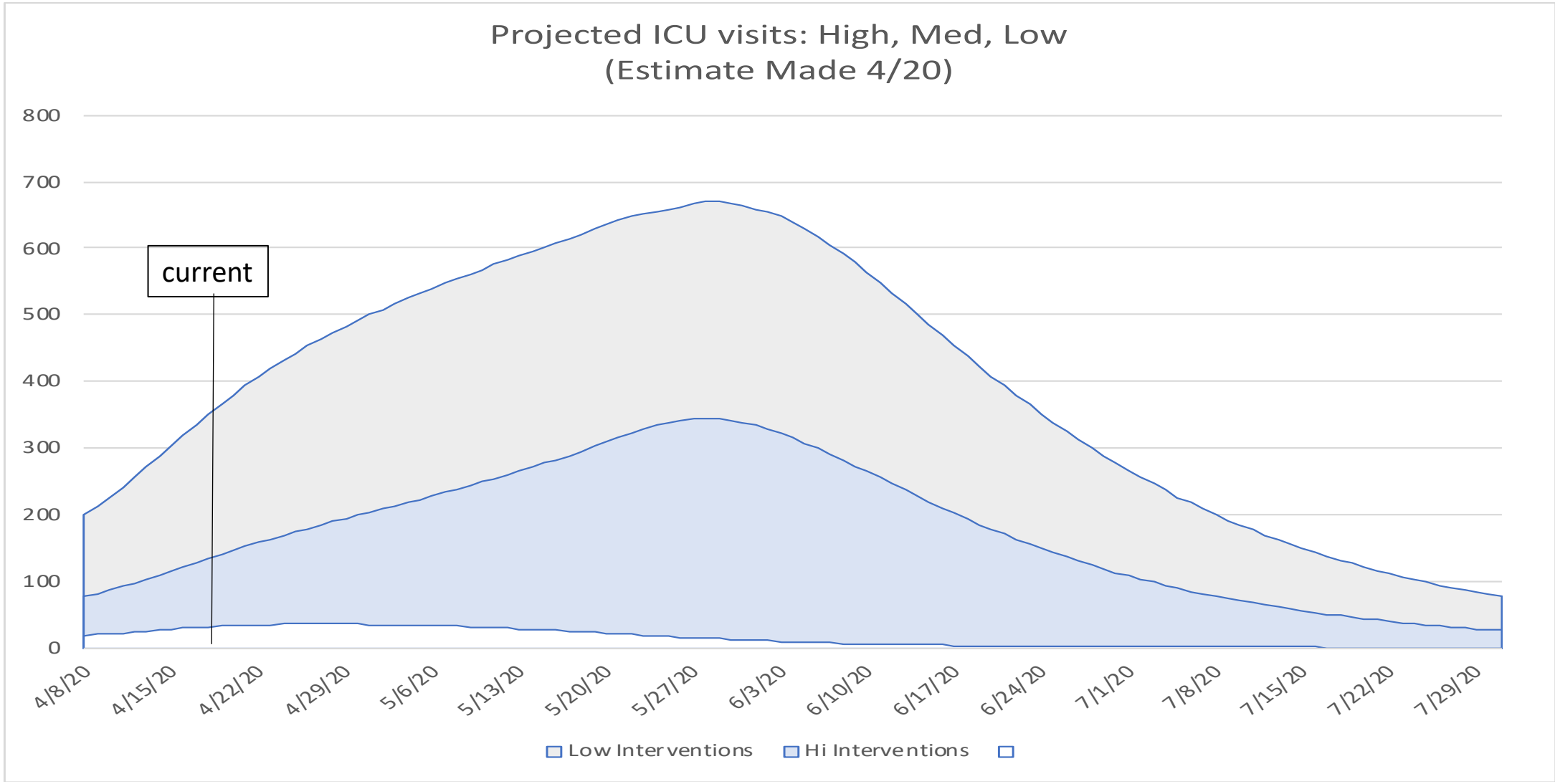
Projected Infections: Low, medium, high



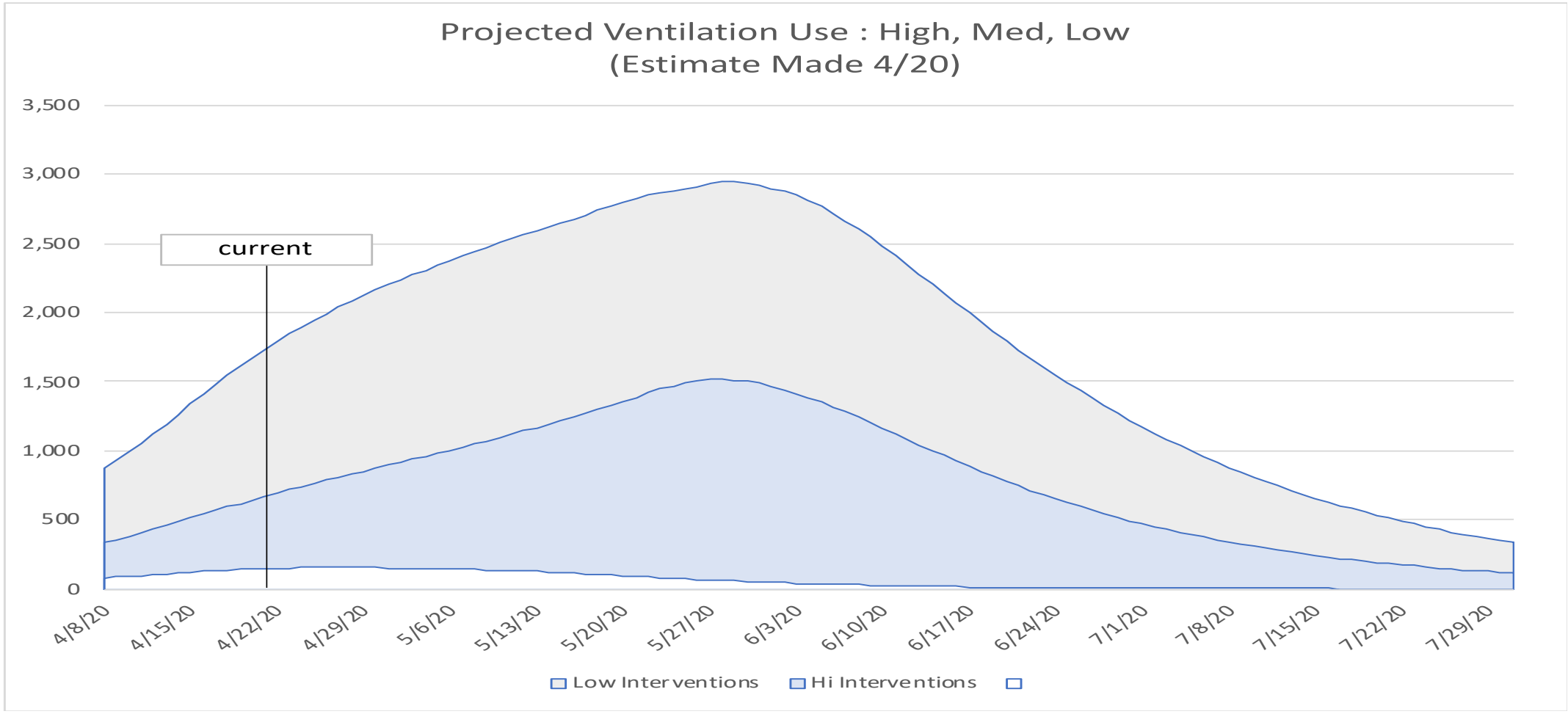
Projected Hospitalizations: Low, medium, high



Projected ICU visits: Low, medium, high



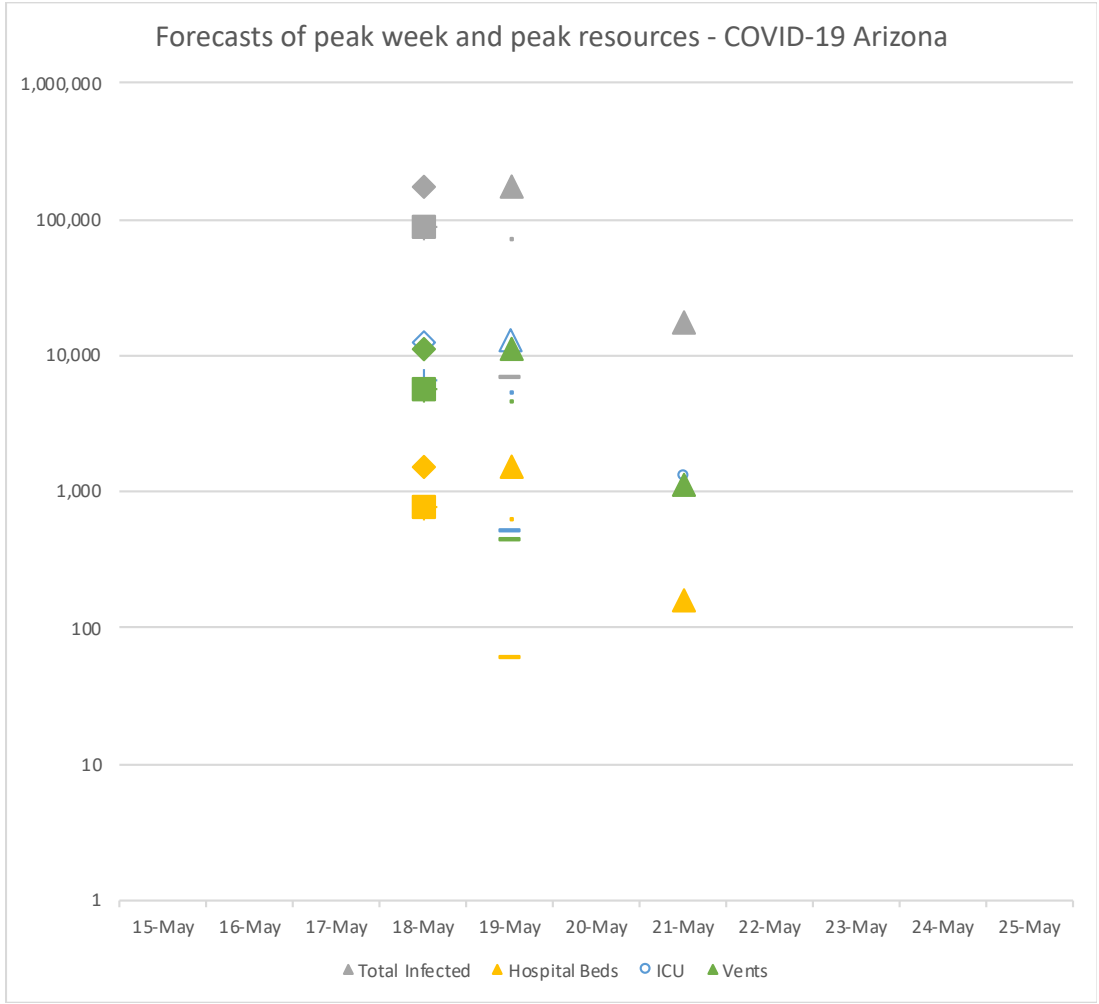
Projected Ventilator Use: Low, medium, high



Assumes 88% ventilator utilization for ICU patients

Model Comparison: All scenarios

- Our model predicts infections will peak around the middle of May
- Model is highly-sensitive to social distancing and increased temperature
- A wide range (1-2 order of magnitude) in outcomes is still feasible with uncertainty in undetected cases



Recommendations:

1. Adopt a baseline planning scenario with “low” and “high” excursions.
2. Discuss & reach consensus on importance of predicting peak week.
3. Update forecasts based on new information weekly(?)
4. Prioritize additional analysis